Multi-Spectral Digital Imaging of Dead Sea Scrolls and Other Ancient Documents

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It is well known that the Dead Sea Scrolls and similar soft media texts are often difficult to read due to the inability of the epigrapher to distinguish the black ink with which they were written from the aged, blacked parchment on which they were inscribed. While considerable success has been achieved in enhancing the readability of these texts through infrared photography, this technique-as conventionally applied today-has distinct limitations. As a result optimal use has not been made of the infrared spectrum and information which should be retrievable has remained lost.

A consortium of researchers from the Ancient Biblical Manuscript Center, the Jet Propulsion Laboratory and West Semitic Research has recently initiated a new set of infrared tests, utilizing multi-spectra imaging techniques, on ancient soft media inscriptions. Application of infrared multi-spectral imaging has revealed hitherto illegible textual information on Dead Sea Scroll fragments made available to the consortium for study. Analysis of the data has made it possible to gain a greater understanding of why infrared photography works so well on ancient texts and has led to substantial improvements in infrared imaging techniques. Moreover, this work has demonstrated that working at wavelengths beyond the sensitivity of infrared film also provides even further improved contrast between text and parchment and that digital image acquisition with a CCD camera is preferred over film as a means of acquiring, controlling and enhancing textual information.

Multi-spectral imaging (MSI) was developed for remote sensing and planetary probes and has recently come into wide use for earth studies, It is used for oceanography, geology, climatology, deforestation and environmental studies. Multi-spectral imaging is a technique for image acquisition and analysis that relies on the unique spectral signature of different parts of the target image (in the case of ancient scrolls, e.g., the ink versus the writing surface). MS I acquires images simultaneously in many narrow, contiguous spectral bands over a spectral range (One might think of this as equivalent to a contiguous set of multi-color images). The advantage of MS I is that its allows the investigator to separate out any part of the target based upon its reflectance spectral signature. When there is a variance in the respective spectral signatures of various parts of a given target (e.g., ink versus writing surface) MSI can enhance this difference using computer imaging analysis techniques. As a result, even reflective differences as small as 2-30A, can be successfully exploited to increase differentiation and hence, in the case of ancient soft media texts, legibility,

We have determined that the recent exceptional success of infrared photography with long-pass filters is due to a broad absorption feature in parchment in the 0.8-0.9 μm region. In this spectral region, instant imaging results are possible with a silicon CCD camera, digital framegrabber and appropriate filters. Text obscured when imagined in this spectral region was revealed when imaged in the 1-3 μm region with a different infrared CCD camera. To take advantage of the large dynamic range inherent in a CCD camera, these images should be taken with a 12 or 16 bit digital camera, one that digitizes the signal immediately after the detector electronics. We anticipate that investigations at even longer wavelengths will also be useful. For example, there is a parchment absorption feature at -9.8 μm that could also be used for contrast enhancement.

Examples illustrating very dramatic gains in legibility of Dead Sea Scroll fragments, utilizing these infrared techniques, will be shown as part of this report.